# Von Bertalanffy GM No Sex Term

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```
LMBL <- read.csv("Data/Clean-Data/2016_largemouth-bass_long-format.csv") %>%
  select(FID:BI.len) %>%
  arrange(FID,Agei)

### Making factors factors
LMBL$FID <- factor(LMBL$FID)
LMBL$Site <- factor(LMBL$Site)
LMBL$SEXCON <- factor(LMBL$SEXCON)
LMBL$Sex <- factor(LMBL$Sex)
```

```
str(LMBL)
```

```
## 'data.frame':    337 obs. of  11 variables:
##  $ FID   : Factor w/ 126 levels "1","2","3","4",..: 1 1 1 1 2 2 2 2 3 3 ...
##  $ Site  : Factor w/ 11 levels "2","4","6","8",..: 6 6 6 6 6 6 6 6 6 6 ...
##  $ AgeCap: int  4 4 4 4 4 4 4 4 4 4 ...
##  $ RadCap: num  0.94 0.94 0.94 0.94 0.988 ...
##  $ LenCap: int  347 347 347 347 292 292 292 292 348 348 ...
##  $ WTg   : int  658 658 658 658 415 415 415 415 557 557 ...
##  $ SEXCON: Factor w/ 5 levels "0","1","3","6",..: 5 5 5 5 3 3 3 3 3 3 ...
##  $ Sex   : Factor w/ 3 levels "0","1","2": 3 3 3 3 2 2 2 2 2 2 ...
##  $ Agei  : int  1 2 3 4 1 2 3 4 1 2 ...
##  $ Radi  : num  0.433 0.69 0.803 0.927 0.567 ...
##  $ BI.len: num  155 252 295 342 165 ...
```

```
headtail(LMBL)
```

```
##     FID  Site AgeCap RadCap LenCap WTg SEXCON Sex Agei   Radi   BI.len
## 1     1    11      4 0.9402    347 658      8   2    1 0.4328 154.6790
## 2     1    11      4 0.9402    347 658      8   2    2 0.6898 252.0903
## 3     1    11      4 0.9402    347 658      8   2    3 0.8028 294.9210
## 335 132 15972      7 1.0474    395 971      3   1    5 0.9567 359.9617
## 336 132 15972      7 1.0474    395 971      3   1    6 1.0119 381.2860
## 337 132 15972      7 1.0474    395 971      3   1    7 1.0365 390.7892
```

```
datgr = groupedData(BI.len ~ Agei|FID, data = LMBL,
                  labels = list(x = "Age", y = "Size"),
                  units = list(x = "(Years)", y = "(mm)"))
```

Creating the von Bertalanffy function.

```
LVB <- function(x, Linf, K, t0){
  y = Linf * (1 - exp(-K * (x - t0)))
  y
}
LVB <- vbFuns()

LVB(5, 422.8, 0.39, -0.40)
```

```
## [1] 371.3351
```

```r
LVB(5, Linf = c(422.8, 0.39, -0.40)) ### Should be the same output
```

```
## [1] 371.3351
```

### nlme mod (No Sex Term)

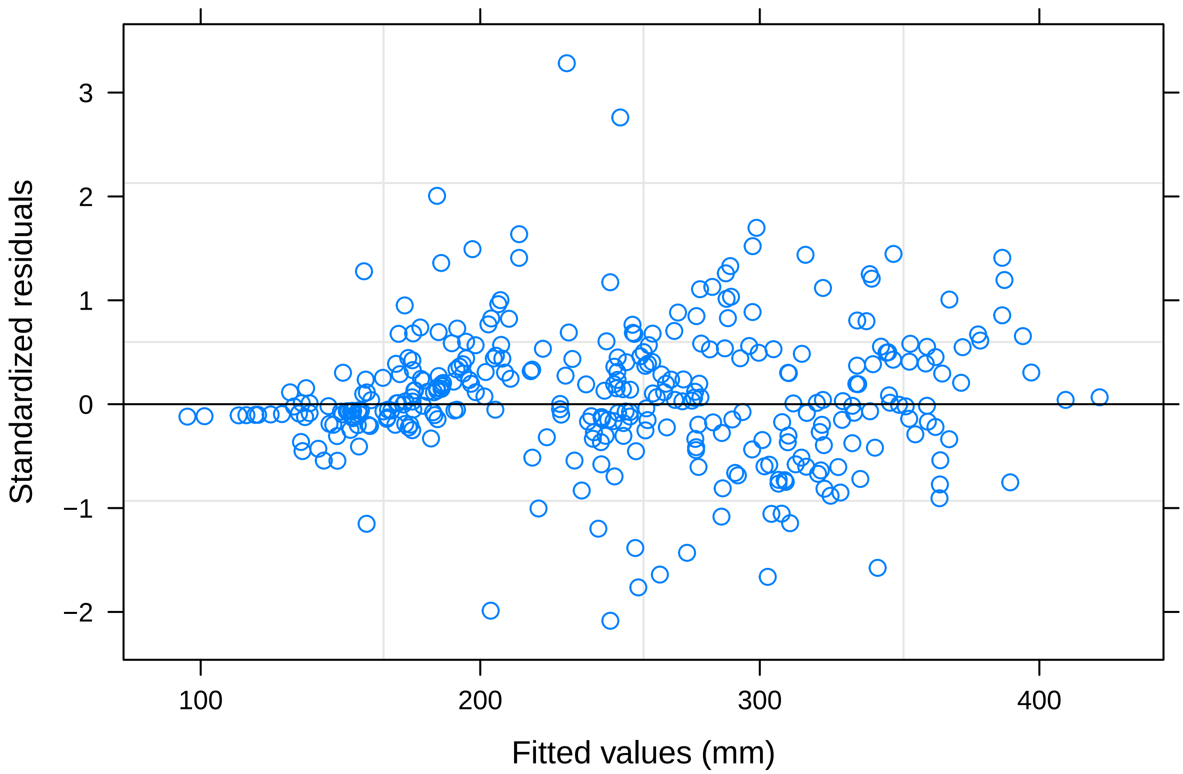
```r
nlme.mod <- nlme::nlme(BI.len ~ LVB(Agei, Linf, K, t0), data = datgr,
                            fixed = list(Linf ~ 1, K ~ 1, t0 ~ 1),
                            random = Linf+K+t0 ~ 1,
                            start = list(fixed =
                                      c(Linf = 389.3647,
                                        K = 0.4359,
                                        t0 = -0.3127)),
                           method= "REML",
                           control=list(opt="nlminb",
                                        maxIter=100,
                                        pnlsMaxIter=100,
                                        msMaxIter=100,
                                        niterEM=100))
#save(nlme.mod,file = "Model-Output/nlme.mod.rda")
```

```
## [1] "Iterations = 4"

## Nonlinear mixed-effects model fit by REML
##   Model: BI.len ~ LVB(Agei, Linf, K, t0)
##  Data: datgr
##        AIC      BIC    logLik
##   2833.928 2872.039 -1406.964
##
## Random effects:
##  Formula: list(Linf ~ 1, K ~ 1, t0 ~ 1)
##  Level: FID
##  Structure: General positive-definite, Log-Cholesky parametrization
##          StdDev     Corr
## Linf     60.8327092 Linf   K
## K         0.1289488 -0.873
## t0        0.4352377 -0.670  0.856
## Residual  4.7627527
##
## Fixed effects: list(Linf ~ 1, K ~ 1, t0 ~ 1)
##         Value Std.Error  DF  t-value p-value
## Linf 425.6965  7.665872 209 55.53139       0
## K      0.4009  0.015719 209 25.50485       0
## t0    -0.3666  0.043430 209 -8.44185       0
##  Correlation:
##    Linf   K
## K  -0.884
## t0 -0.609  0.804
##
## Standardized Within-Group Residuals:
##        Min         Q1        Med         Q3        Max
## -2.0847753 -0.1981814  0.0278886  0.4229808  3.2823985
##
```

```
## Number of Observations: 337
## Number of Groups: 126
```

```
## Approximate 95% confidence intervals
##
##  Fixed effects:
##            lower        est.       upper
## Linf 410.5841783 425.6965204 440.8088624
## K      0.3699297   0.4009183   0.4319070
## t0    -0.4522482  -0.3666309  -0.2810135
## attr(,"label")
## [1] "Fixed effects:"
##
##  Random Effects:
##   Level: FID
##                     lower       est.      upper
## sd(Linf)     47.75866119 60.8327092 77.4858093
## sd(K)         0.09216863  0.1289488  0.1804062
## sd(t0)        0.36935346  0.4352377  0.5128741
## cor(Linf,K)  -0.93279735 -0.8731908 -0.7670862
## cor(Linf,t0) -0.81409867 -0.6699900 -0.4481523
## cor(K,t0)     0.75059662  0.8559247  0.9188331
##
##  Within-group standard error:
##    lower     est.    upper
## 4.015377 4.762753 5.649237
```

```
##      numDF denDF  F-value p-value
## Linf     1   209 39477.28  <.0001
## K        1   209  2945.99  <.0001
## t0       1   209    71.26  <.0001
```




```r
fixef(nlme.mod)
```

```
##        Linf           K          t0
## 425.6965204   0.4009183  -0.3666309
```

```r
ranef(nlme.mod)
```

```
##            Linf            K           t0
## 88  -93.7655080  0.254102333  0.850327251
## 87  -89.5309586  0.241018178  0.807633915
## 85  -80.2756842  0.213040893  0.717194451
## 86  -78.0302853  0.206370369  0.695787193
## 83  -75.3219004  0.198380479  0.670217061
## 27  -74.4837813  0.195920011  0.662357689
## 89  -70.5055240  0.184315577  0.625378025
## 69  -66.7437139  0.173450991  0.590875294
## 84  -60.7334347  0.156297618  0.536593022
## 82  -56.7359272  0.145020539  0.501000964
## 110 -43.7085356  0.108951631  0.387272004
## 76  -40.9992916  0.101578141  0.363955618
## 80  -40.2353417  0.099507050  0.357396318
## 74  -39.0369131  0.096265119  0.347117958
## 78  -38.2839127  0.094232701  0.340666810
## 77  -37.9900873  0.093440611  0.338150867
## 75  -35.4334599  0.086571503  0.316286181
## 72  -34.1825761  0.083226102  0.305602753
## 121 -34.1367211  0.083103665  0.305211262
## 73  -10.2531257  0.022104939  0.098367680
## 7    -5.1373475  0.010435941  0.050915992
## 70    5.4358424 -0.009054611 -0.058044561
```

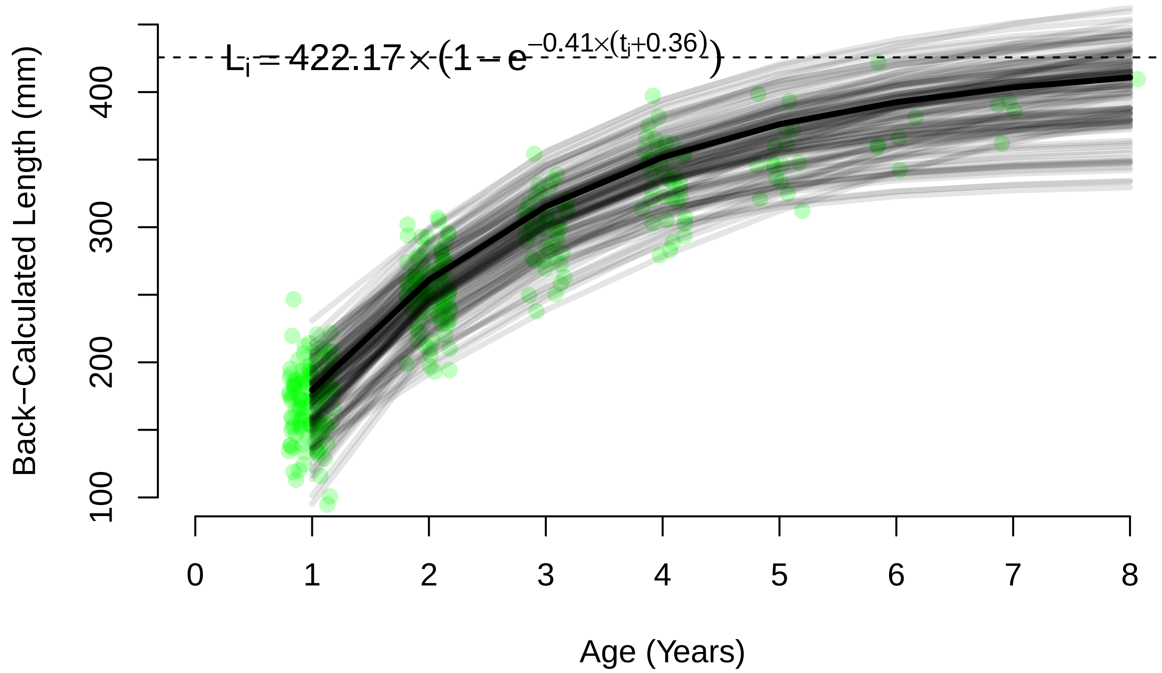
```
## 35     5.4592382 -0.009087252 -0.058306379
## 122    6.9699866 -0.011073280 -0.075396289
## 96     7.5302443 -0.011747867 -0.081819863
## 16    12.3531788 -0.016174613 -0.138395152
## 39    14.1472228 -0.017237878 -0.159646049
## 104   83.1805110 -0.226345819 -0.421180510
## 29    16.5716994 -0.018262076 -0.188133723
## 71    76.1181072 -0.217421642 -0.502318020
## 15    20.4980390 -0.019143259 -0.233057683
## 34    22.2430684 -0.019305381 -0.252387533
## 119   68.5556673 -0.189287798 -0.261228152
## 65   -87.3945906  0.159934847  0.434778395
## 91   -71.8797729  0.164307295  0.529623403
## 63   -72.5208369  0.157019130  0.493945783
## 107   50.9380516 -0.170610018 -0.559899453
## 64   -40.6743335  0.042804181  0.161924862
## 67   -44.5197633  0.061143030  0.206853864
## 58    40.5098677 -0.145836216 -0.526376796
## 120   38.8853475 -0.135024683 -0.420431485
## 111   13.3701851 -0.070680594 -0.082612646
## 66    35.2282493 -0.123895270 -0.368067142
## 131  -39.9027149  0.107761773  0.392898942
## 68    17.5988554 -0.078215182 -0.138379185
## 106  -32.8342277  0.098353224  0.369698476
## 130  -30.9233230  0.087232442  0.328753142
## 98   -31.5441222  0.122549806  0.471819735
## 56   -30.4175534  0.098318308  0.373911453
## 62    16.2260378 -0.070960912 -0.180191484
## 112  -12.1176351  0.009225910  0.074871498
## 126    3.7573486 -0.034119839 -0.066668531
## 53    -4.9322721 -0.008237626  0.016178226
## 115  -19.5897005  0.055708011  0.221511133
## 117   13.7330580 -0.053081267 -0.205915325
## 33     6.0197569 -0.026408005 -0.085735797
## 99   -15.1967909  0.090824135  0.362590935
## 108  -11.5832215  0.066657109  0.265891961
## 127  -13.0763895  0.090891072  0.364520334
## 95     6.4447668 -0.014588334 -0.063531173
## 57    17.9159489 -0.060167949 -0.331951918
## 102    1.7147396  0.020904280  0.075744444
## 100    8.9650067 -0.014620009 -0.080450062
## 8     15.7849615 -0.035082721 -0.212953075
## 125    4.6771434  0.067692615  0.268132168
## 123   15.9741933 -0.018372610 -0.144805850
## 14    20.4862748 -0.045252794 -0.338809870
## 23    21.9593209 -0.047771744 -0.393442937
## 54    16.3288729  0.049478834  0.174557258
## 52   -73.3878437  0.167216683  0.497155460
## 2     46.2684987 -0.225471248 -0.964255731
## 97    18.8247175  0.081900056  0.325276646
## 18   -60.6897244  0.065822138  0.075977175
## 92    24.2833476  0.061999373  0.225010550
## 19    30.5406512 -0.017638826 -0.245465882
## 114   30.2783334  0.013437375 -0.045038926
```

```
## 101  30.5900672  0.054245365  0.177186538
## 25   32.0130709  0.004888832 -0.102958124
## 45   32.7407168  0.055482821  0.180262579
## 43  -24.1980353  0.001771404 -0.070703355
## 36  -41.2370782  0.071076175  0.069316779
## 90   41.4174993  0.022939601 -0.022754211
## 46   32.1206158 -0.045481794 -0.608836678
## 61   12.0809816 -0.081178442 -0.435853646
## 17  -17.1189292  0.009467309 -0.098306636
## 118  24.1400040 -0.070149278 -0.174038710
## 60  -37.5590692  0.010448970  0.085143563
## 113 -57.4836597  0.105911110  0.232544310
## 47   36.6778559 -0.194094834 -0.512475080
## 103  85.0945465 -0.184806818 -0.253603681
## 30   21.6241329 -0.113606416 -0.274434821
## 94   13.0463836 -0.109045286 -0.510903418
## 50    7.6772732 -0.160758874 -0.754503398
## 32   18.8423544 -0.011500207 -0.219451161
## 129 -31.3895085  0.048286533  0.141988495
## 51  -26.2563435 -0.085581390 -0.408891614
## 31   48.4141916 -0.129249249 -0.266371420
## 3   -28.8049055  0.042189431 -0.064866856
## 1   -28.2235852  0.066161338  0.294133556
## 109 -22.1428517 -0.033826426  0.184543733
## 21  -16.9999997  0.027025016 -0.021977793
## 59  -30.1476525 -0.035440764 -0.279231852
## 116 -34.0509764  0.016645187  0.222360867
## 48    6.3788969 -0.022631486  0.048965519
## 38  -12.9872176 -0.017337489 -0.537493698
## 93  -10.8413781  0.046596875  0.142831978
## 41   75.8494011 -0.150791340 -0.361141014
## 20   47.9671915 -0.123178187 -0.572165599
## 105   7.5355958 -0.062207231 -0.643223351
## 5    49.5248474 -0.081452492 -0.063056461
## 4    36.8841703 -0.173255202 -0.442855846
## 128  78.1186269 -0.174222121 -0.143621610
## 42   -0.2860772  0.024116903 -0.143235143
## 49   71.1358837 -0.233586456 -0.542669407
## 44   32.5580286 -0.067297659 -0.243573735
## 22    8.2148233  0.031849559  0.106664425
## 13   70.3178106 -0.178991963 -0.730004858
## 12    0.8241870 -0.018052706 -0.006550835
## 9    39.5732351 -0.046386743 -0.183247825
## 40   68.1604558 -0.076820382 -0.130041373
## 26   45.1782200 -0.162970172 -0.015381762
## 132 -24.6260301  0.069678281  0.290659452
## 37   89.1641423 -0.163747006 -0.523779348
## 11   52.8137176 -0.025319517 -0.252902255
## 10  113.7101496 -0.240192906 -0.486463371
## 24   56.8967254 -0.063958567  0.229931178
```

```
coef(nlme.mod)[1,3]
```

```
## [1] 0.4836964
```

```r
Axes <- seq(100,450,by=50)
Years <- seq(0,8,by=1)

## plot individual fish data
## plot the fixed parameter model
## plot individual fish models

plot(jitter(LMBL$Agei),LMBL$BI.len,
     col=rgb(0,1,0,0.25, maxColorValue=1),
     pch=19,
     ylim=c(100,450),
     xlim=c(0,8),
     xlab = "Age (Years)",
     ylab = "Back-Calculated Length (mm)",
     bty="n",
     yaxt="n",
     xaxt="n")

axis(2,at = Axes)
axis(1,at = Years)

abline(h=425.6965204,lty=2)

x <- seq(1,8,by=1)
lines(x, fixef(nlme.mod)[1] * (1 - exp(-fixef(nlme.mod)[2] * (x - (fixef(nlme.mod)[3])))),
      lwd=3,
      col="black")

for(i in 1:125){
lines(x, coef(nlme.mod)[i,1] * (1 - exp(- coef(nlme.mod)[i,2]
* (x - ( coef(nlme.mod)[i,3] )))),lwd=3,col=gray(0,0.1)) }

legend("topleft",
       legend = print(expression(L[i]==422.17 %*% (1 - e **{-0.41 %*% (t[i] + 0.36)}))),
       bty="n",
       cex=1.15)
```




```
## expression(L[i] == 422.17 %*% (1 - e^{
##     -0.41 %*% (t[i] + 0.36)
## }))
```